67 | Sensation

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Definition

The sensory system provides information that places the individual in relation to the environment. Sensation may be classified into categories by various methods dependent on anatomic or functional criteria. An anatomic classification divides sensory function into somatic and visceral components with general and special subgroups of each. Clinically, however, only somatic sensation is easily measured. One functional classification separates sensory modalities into simple affective sensations, termed *protopathic,* and sensations that provide discriminative analysis with regard to the environment, termed *epicritic.* A more practical scheme of classification was developed early in this century by Sherrington and remains the most useful for the clinician. This scheme utilizes both anatomic criteria including the types and locations of end organs and functional criteria such as the types of stimuli measured by each modality to separate *exteroceptive* and *proprioceptive* sensation. A third sensory modality requires cortical analysis to provide more complex interpretation of primary sensory information. All three types of sensation should be evaluated in every patient examined.

Exteroceptive sensation (also termed superficial sensation): receptors in skin and mucous membranes

Tactile or touch sensation (thigmesthesia):
  Anesthesia: absence of touch appreciation
  Hypoesthesia: decrease of touch appreciation
  Hyperesthesia: exaggeration of touch sensation, which is often unpleasant
  (Terms above are unfortunately used indiscriminately to apply to losses of all types of sensation. They are not specific for loss of tactile sensation.)
Pain sensation (algesia):
  Analgesia: absence of pain appreciation
  Hypoalgesia: decrease of pain appreciation
  Hyperalgesia: exaggeration of pain appreciation, which is often unpleasant
Temperature sensation, both hot and cold (thermesthesia):
  Thermanalgesia: absence of temperature appreciation
  Thermhypesthesia: decrease of temperature appreciation
  Thermhyperesthesia: exaggeration of temperature sensation, which is often unpleasant
Sensory perversions (see Chapter 52, Pain and Sensory Perversions):
  Paresthesia: abnormal sensations perceived without specific stimulation. They may be tactile, thermal or painful; episodic or constant.
  Dysesthesia: painful sensations elicited by a nonpainful cutaneous stimulus such as a light touch or gentle stroking over affected areas of the body. Sometimes referred to as hyperpathia or hyperalgesia. Often perceived as an intense burning, dysesthesias may outlast the stimulus by several seconds.

Proprioceptive sensation (also termed deep sensation): receptors located in muscles, tendons, ligaments and joints
  Joint position sense (arthresthesia): Absence is described as such
  Vibratory sense (pallesthesia): Absence is described as such
  Kinesthesia: perception of muscular motion. Usually not measured in routine clinical evaluation.
Cortical sensory functions: interpretative sensory functions that require analysis of individual sensory modalities by the parietal lobes to provide discrimination. Individual sensory modalities must be intact to measure cortical sensation.
Stereognosis: ability to recognize and identify objects by feeling them. The absence of this ability is termed *astereognosis.*
Graphesthesia: ability to recognize symbols written on the skin. The absence of this ability is termed *graphanesthesia.*
Two-point discrimination: ability to recognize simultaneous stimulation by two blunt points. Measured by the distance between the points required for recognition. Absence is described as such.
Touch localization (topognosis): ability to localize stimuli to parts of the body. *Topagnosia* is the absence of this ability.
Double simultaneous stimulation: ability to perceive a sensory stimulus when corresponding areas on the opposite side of the body are stimulated simultaneously. Loss of this ability is termed *sensory extinction.*

Technique

The sensory examination is the most subjective part of the neurologic examination. Although seemingly simple in technique, it must be performed carefully with optimal patient cooperation to achieve reliable results. The patient should be relaxed and in comfortable surroundings. Care must be taken to explain to the patient what is expected of him or her and to assure anxious patients that the examination will not be painful. Accurate results are difficult to obtain if the patient is distracted or exhausted. In such cases, the examination should be repeated when the patient is rested. Areas of abnormal sensation should be outlined on the patient with a skin pencil and findings should be meticulously recorded on an outline of the body with a description of the stimuli used.

Before starting the examination, the patient should be questioned as to whether abnormal sensations are experienced subjectively. The patient should be asked if any parts of the body feel numb or are painful, or if paresthesias or dysesthesias are experienced. If the patient replies positively to such questions, the examination can then be tailored to direct more attention to the involved areas.

Screening examinations on patients in whom no sensory disturbances are suspected can be reliably performed by testing touch (with double simultaneous stimulation), pain

or temperature, joint position, and vibratory sensibilities in a few well-chosen locations. This need take only 3 to 5 minutes. A more detailed examination must be done when disturbances are suspected after the history or uncovered on screening examination. In such cases, the examiner should direct the examination at discovering the anatomic basis of the sensory findings. An adequate working understanding of the neuroanatomy of the sensory system is essential for performance of a thorough examination.

The sensory examination in its entirety is given in this chapter. On most occasions, it is best done in a segmental fashion (e.g., include the sensory testing of the upper extremity with the rest of the upper extremity examination). Abnormal findings should always be rechecked on a second occasion to assure their validity.

Exteroceptive Sensation

Tactile sensation. Areas of the face, trunk, and extremities should be touched lightly with a wisp of cotton, a small piece of paper, or the gentlest possible touch of your fingerpads. Care must be taken to touch lightly, as stronger stimuli may activate deep pressure receptors in addition to superficial tactile receptors. With eyes closed, the patient should be asked to reply "yes" each time a stimulus is applied. Tactile localization can be tested by having the patient point to the area stimulated or to describe the area tested. Double simultaneous stimulation can be tested by touching each side of the body simultaneously.

On a screening examination, it is sufficient to touch on each side of the body in the distribution of each of the three trigeminal divisions, each upper extremity in three locations, and the same for the trunk and lower extremities. On the extremities, proximal and distal responses should be compared. If an area of sensory loss is discovered, it is often useful to have the patient aid in outlining the boundaries with his fingertips. Care should be taken not to apply the stimuli in a rhythmic manner, otherwise the patient may be able to anticipate the stimuli or may be lulled into an inattentive state by the rhythmic nature of the stimuli.

The method described above is sufficient in most situations. Sekuler et al. (1973) have described a two-alternative forced-choice procedure that is more reproducible and accurate, albeit time consuming. Other investigators have compared detailed quantitative testing with clinical testing of sensation and found good correlation between the two (Dyck et al., 1976).

Pain sensation. Painful stimuli are most easily applied by use of a safety pin using the point and guard in a random fashion to assess reliability and attention. The patient should reply "sharp" or "dull" with eyes closed.

Evaluate the same areas tested in the screening examination for tactile sensation. Each side should be compared with the other, and distal and proximal portions of each extremity should be tested. If areas of analgesia or hypalgesia are discovered, stimulate from areas of diminished sensibility to the normal areas as the onset of painful stimulus is better perceived than attenuation or cessation of the stimulus.

Slight changes in sensation can sometimes be demonstrated by drawing the point of the pin lightly over the skin. A tailor's marking wheel is sometimes used to delineate large areas of diminished sensibility. If tested too rapidly with either technique, however, the area of subjective hypoalgesia may appear larger than it actually is. As it may be possible to transmit communicable diseases by transferring small amounts of blood produced by pinprick, instruments should be cleaned between patients.

Temperature sensation. Apply cool and warm objects to parts of the body described above in screening. Test tubes filled with warm water or cracked ice and water may be used for testing. Temperatures less than 5°C or greater than 45°C elicit painful responses in addition to temperature and should be avoided. With eyes closed, have the patient describe the stimulus; simple responses of hot or cold may mask subtle changes in temperature sensibility. In screening examinations, a tuning fork can be used to provide a cool object. Temperature testing is often a more sensitive measure of subtle dysfunction than pain testing.

Proprioceptive Sensation

Joint position sense. The most distal joints of each extremity are tested first because most disturbances of proprioception involve distal before proximal joints. If testing on the distal joint is abnormal, more proximal joints should be tested successively until a normal joint is reached. If the distal joint appears normal, there is rarely a need to test more proximal joints. The third and fourth digits of both upper and lower extremities are more likely to show early proprioceptive dysfunction as they are more sparsely innervated than the first, second, or fifth digits.

The digit tested should be separated from its mates so as not to provide tactile clues to movement. After grasping the lateral surfaces of the digit proximal to the joint with thumb and forefinger, place the thumb and forefinger of the other hand distal to the joint and parallel to the plane of movement. This avoids production of pressure stimuli on the surface of the digit, which might provide clues to the patient. Show the patient up or down movements and instruct him or her to reply "up" or "down." After making sure the instructions are understood, move the digit through random small up or down movements and have the patient respond with eyes closed. An alternative method is to test threshold to movement by making initially very small and then successively larger movements of the joint and have the patient respond when movement is perceived. A normal individual can perceive movements of one or two degrees in the digits and even smaller excursions in more proximal joints. Sensitivity is less when the joint is in midposition (see Basic Science).

In patients with decreased sensation or those unable to cooperate with detailed testing, joint position sense can be roughly assessed in the upper extremity by placing the digits of one of the patient's hands in a certain position and asking him or her to imitate the position in the other with eyes closed. To test the lower extremity, the patient's foot can be moved and the patient asked to point to the great toes with eyes closed. The Rosenberg test is also a test of joint position sense. This test is performed by having the patient stand with heels together and close his or her eyes. Stand close to the patient to prevent a fall. If position sense is diminished, the patient will sway severely or fall. Patients with cerebellar disease will sway with eyes open or closed.

Vibratory sense. As with position sense, more distal joints should be tested first as dysfunction will be manifest earliest distally. The third and fourth digits are preferable for detecting mild proprioceptic loss as noted above. If vibration is not perceived on distal joints, testing should be continued proximally over joints or bony prominances until it is per-

ceived, and the location noted. A 128 Hz or C tuning fork should be used, as this frequency provides a clearer separation of normal from abnormal than 64 or 256 Hz tuning forks. Proper application of the tuning fork is illustrated in Figure 67.1.

The timed vibratory test is the most sensitive simple method of detecting mild to moderate impairments in vibratory sensation. Strike the tuning fork maximally, noting the time on the second hand of a watch. Apply the fork to the most distal joint of both upper and lower extremities as illustrated, and ask the patient to describe what is felt. Usually the patient will say "buzzing" or "like electricity." Instruct the patient to indicate instantly when the sensation stops and note the total elapsed time since the fork was struck. The range of normal for this test will depend on you and your tuning fork. After testing a range of normal individuals and individuals with peripheral neuropathy (i.e., diabetics or alcoholics with impaired joint position sense and absent ankle jerks), the test can be "standardized" in your hands.

Another method of determining mild or moderate impairment of vibrating sensation is for the examiner to place his or her finger on the opposite surface of the joint tested from the tuning fork. Assuming normal sensation in the examiner, the patient should be able to feel the vibration as long as the examiner. For more detailed testing of vibratory sensation, electronically stimulated vibrating devices can be used to provide a quantitative measurement of vibrating threshold. These are not generally helpful in routine clinical practice.
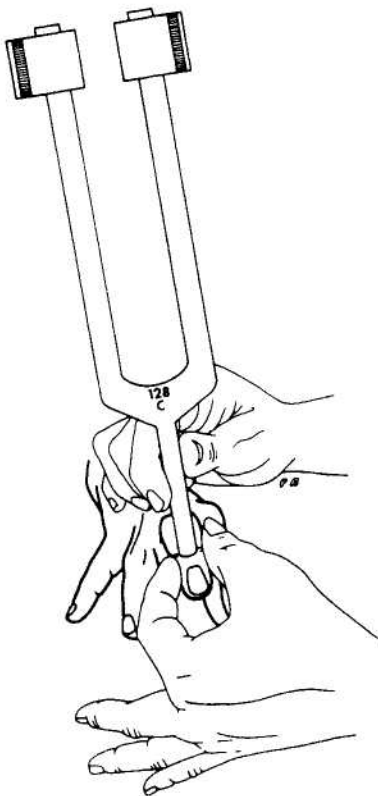
Figure 67.1
The timed vibratory test. The patient's hand is in heavy outline.

Cortical Sensory Function

Cortical sensory functions can be tested only when exteroceptive and proprioceptive sensations are normal.

Stereognosis. Objects such as a pen, key, comb, or paperclip are placed in the patient's hand. With eyes closed, the patient is asked to describe or identify the objects. For more detailed testing, the patient may be asked to differentiate coins or identify letters carved out of wood. Care should be taken not to provide auditory clues.

Graphesthesia. With the patient's eyes closed, ask him or her to identify letters or numbers written on the skin with a pencil or dull pin.

Two-point discrimination. With the patient's eyes closed, use a pair of measured calipers or a bent paperclip to touch the patient randomly with either one or two points and have the patient indicate whether one or two points are perceived. Start with the points relatively far apart and approximate the points until the patient makes errors. Compare opposite sides of the body. The minimum separation at which the patient can reproducibly differentiate two points is noted. Ordinarily, only the fingerpads are tested but other areas of the body can be tested in selective circumstances. According to DeJong (1967), the following are the normal distances at which two points can be discriminated on various body parts:

Tongue tip: 1 mm

Fingertip: 2 to 4 mm

Dorsum of fingers: 4 to 6 mm

Palm: 8 to 12 mm

Dorsum of hand: 20 to 30 mm

Topognosis. Ask the patient to describe or point to various parts of the body tested with tactile stimulation. This can be done with tactile testing.

Double simultaneous stimulation. This can also be done as part of tactile testing. With the patient's eyes closed, ask him or her to localize the tactile stimulus. Test one or both sides on various body parts in nonrhythmic fashion. Patients with parietal lobe lesions may recognize stimuli on one side of the body when applied independently but not recognize or distinguish that stimulus when bilateral stimuli are applied.

Basic Science

An understanding of the neuroanatomy of the sensory system can provide the clinician with valuable assistance in the localization of lesions of the nervous system. Structures involved in perception of exteroceptive and prioprioceptive sensation can be identified as follows, starting peripherally:

Receptor	
Peripheral nerve	first neuron
Dorsal root ganglion	
Spinal cord neuron	second neuron
Thalamic nucleus	third neuron
Cerebral cortex	fourth neuron

Several cutaneous sensory receptors have been identified including free nerve endings and multiple types of elaborate encapsulated endings such as pacinian corpuscles, Merkel disks, and Meissner corpuscles. Physiologic experiments have

shown that specific points on the skin respond to pressure, pain, hot or cold and that the density of such points varies for different sensory modalities; for example, there are more pain points than pressure or temperature points. For the greater part of a century, controversy has existed about whether there are specific cutaneous receptors for each sensory modality. Against this view is the finding that different areas of skin contain different types and densities of receptors, but all areas are capable of perceiving all sensory modalities, albeit with different sensitivities. For example, skin on the ear contains only two types of nerve endings but is sensitive to touch, pain, heat and cold. An important point that has a bearing on this question is that sensation as perceived, interpreted, and verbally expressed by the brain involves the integration of many different impulses.

Sensory fiber tracts cross between entry at the spinal cord and the thalamus so that all modalities of sensation are recognized in the cerebral cortex contralateral from the applied stimulus. The exact site of crossing depends on the modality. Thus, lesions in certain locations in the spinal cord or brainstem can affect specific sensory modalities and not others, producing a disassociation of sensory loss. Figure 67.2 illustrates the spinal cord structures involved in sensation.

Pain and Temperature

Nerve endings that respond specifically to temperature have not been identified. Temperature points are well described on the skin that respond to both cold and warm with the density of cold spots greater than that of warm. Single nerve fibers have also been identified that respond electrophysiologically to cold or hot sensations, with temperature changes as small as 0.2°C producing significant discharges of the fibers. Fibers respond both to absolute temperature and to changes in temperature. This can be easily tested by placing one hand in cold water and the other in warm water, then quickly transferring both hands to the same dish of lukewarm water. After doing so, the first hand will perceive the water as warm and the second as cold.

Pain receptors have been identified as free nerve endings. Two fiber types are involved in the transmission of

pain impulses. *A-delta fibers* are small myelinated fibers that carry "fast pain." This is an immediate, distinct, well-localized sensation such as that made by penetration of a needle. It abates after the stimulus is withdrawn. *C-fibers* are very small unmyelinated fibers that carry "slow pain." This is an intense but more diffuse and less well-localized sensation that is less bearable than fast pain. Slow pain may persist for an interval after the stimulus is withdrawn. Fibers of both types pass via peripheral nerves to the dorsal root ganglion where the cell bodies of the first neuron are located. The fibers traverse the lateral portion of the dorsal root and enter the spinal cord. Most fibers then enter Lissauer's tract and ascend or descend one or two segments before synapsing on stellate cells in the substantia gelatinosa. Some fibers pass directly to the substantia gelatinosa and synapse, while other fibers probably synapse on cells in the nucleus centrodorsalis (central magnocellular nucleus) of the posterior gray horn.
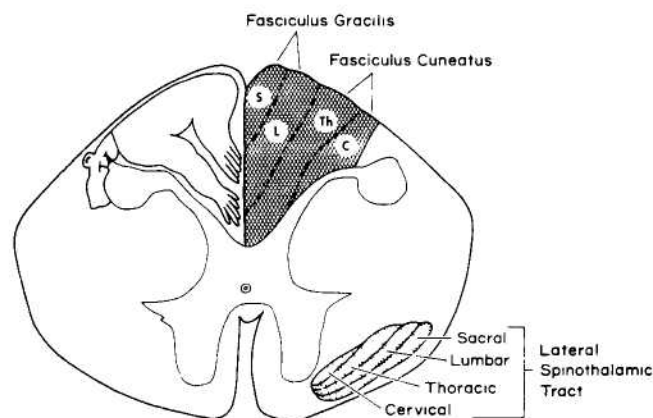
The neuraxes of neurons of the next order cross the midline of the cord anterior to the central canal in the anterior commissure and pass to the third-order neurons in the thalamus. The A-delta fibers ascend in the lateral spinothalamic tract. This pathway is laminated with fibers from lower regions of the body more lateral and closer to the surface of the cord. The majority of fibers end in the posterior nuclei of the thalamus; some fibers end in the ventral posterolateral nucleus (VPL). C-fibers ascend in the anterior spinothalamic tract and terminate in the intralaminar and parafascicular nuclei of the thalamus. C-fibers send collaterals to the reticular formation and to the hypothalamus, thus providing alerting and autonomic responses to pain. This system is more diffuse than the fast pain or delta fiber system.

Pain fibers are arranged topographically in the thalamus with fibers from lower portions of the body placed laterally and rostrally, fibers from the upper portions of the body in an intermediate position, and fibers from the bone more medially and caudally. Very little is known of central temperature connections. It can be said that lesions that cause disturbances in pain sensation almost invariably cause disturbances in temperature perception.

From the thalamus, third-order pain fibers pass to the somesthetic cortex on the posterior lip of the rolandic fissure in the parietal lobe. At the cortex, a topographic arrangement of pain fibers is maintained with fibers carrying sensation from the lower extremities curved medially to the surface of the superior longitudinal fissure, those from the hand to the midportion of the surface of the parietal lobe, and those from the face to the inferior portion of the postcentral gyrus (Figure 67.3).

The role of the cortex in pain perception is complex and poorly understood. Three areas are involved:

- Somatosensory area I: the postcentral gyrus
- Somatosensory area II: located at the base of the precentral and postcentral gyri, extending back to the parietal region
- Supplementary motor area (Ms II of Woolsey): located parasaggitally on the medial surface of the cortex over the representation of the foot in the precentral gyrus

Fasciculus Gracilis

Fasciculus Cuneatus

Sacral
Lumbar
Thoracic
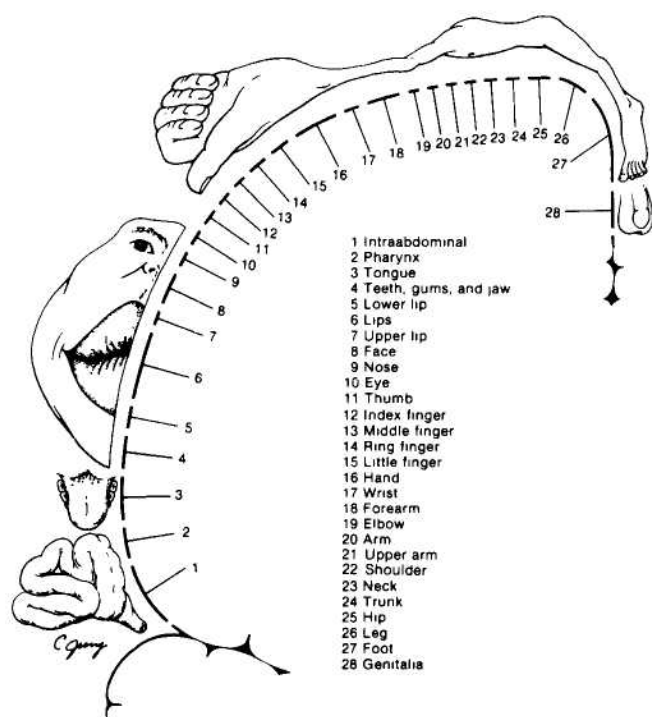Cervical

Lateral
Spinothalamic
Tract

Figure 67.2
The posterior (dorsal) columns and lateral spinothalamic tract in the spinal cord. Modified and used with permission of: Walker AE. *Arch Neurol Psychiat* 43:284–298, © 1940, 1976 AMA; Humphrey T: *Arch Neurol Psychiat* 73:36–46, © 1955, 1976 AMA; Foerster O, Gagel O: *Zbl Ges Neurol Psychiat* 138:1–92, 1932.

Proprioception and Vibration

Information concerning limb position is provided by three principal receptor groups: (1) stretch receptors in skeletal

1 Intraabdominal
2 Pharynx
3 Tongue
4 Teeth, gums, and jaw
5 Lower lip
6 Lips
7 Upper lip
8 Face
9 Nose
10 Eye
11 Thumb
12 Index finger
13 Middle finger
14 Ring finger
15 Little finger
16 Hand
17 Wrist
18 Forearm
19 Elbow
20 Arm
21 Upper arm
22 Shoulder
23 Neck
24 Trunk
25 Hip
26 Leg
27 Foot
28 Genitalia

Figure 67.3
Homunculus showing cortical sensory representation. Modified from Penfield W, Rasmussen T. The cerebral cortex of man. New York: Macmillan, 1950. Used with permission from DeJong, R.N. The Neurological Examination, 4th ed. New York: Harper & Row, 1979.

muscles and tendons; (2) skin mechanoreceptors; and (3) joint mechanoreceptors. Impulses arising from muscle spindles and tendon organs are discussed in Chapter 72, Deep Tendon Reflexes. Electrophysiologic studies of joint fibers have shown that fibers respond to the position of the joint at the end of movement as well as the velocity, acceleration, and direction of movement. Pain fibers are also located in joints. Discharge rates from joint fibers are greatest during movements when the joint is flexed or extended and least when the movements are made with the joint in midposition. This is in accordance with clinical observations.

The receptors for vibratory sensibility are believed to be pacinian corpuscles. They are present in the subcutaneous connective tissue, especially in the fingertips, palms, toes and soles of the feet, as well as in the periosteum of the bones and joint capsules. Physiologically, these structures are acceleration detectors, responding best to sinusoidal stimulation with frequencies of 100 to 160 Hz in a 1:1 fashion.

Proprioceptive and vibratory sensations are transmitted by large myelinated A-fibers that pass to the dorsal root ganglia and traverse the medial portion of the dorsal root to enter the spinal cord. After entering the spinal cord, fibers pass in three divergent roots. Some pass to synapse on lower motor neurons in the ventral gray horn to form the stretch reflex arc. Others ascend in both crossed and uncrossed spinocerebellar pathways to pass to the cerebellum. A third group of fibers passes into the ipsilateral dorsal column and ascend to synapse on second-order neurons in the nucleus gracilis and nucleus cuneatus in the medulla. Within the dorsal column, fibers from lower parts of the body occupy a medial position with higher entering fibers ascending laterally. The fasciculus gracilis transmits fibers

from sacral, lumbar, and low thoracic regions and the fasciculus cuneatus from upper thoracic and cervical regions. The sensibilities carried by the dorsal columns are (DeMyer, 1975):

- Position sense
- Vibratory sense
- Kinesthesia (sensation of movement)
- Pressure sense

Allied discriminative sensations include:

- Texture recognition
- Topagnosis
- Two-point discrimination
- Barognosis (recognition of weight)
- Graphesthesia

Neurons in the nuclei gracilis and cuneatus display a topographic orientation with a complex physiologic organization. Spatial inhibition of the center-surround type has been demonstrated as in the visual system (see Chapter 115, Visual Acuity). Descending cortical influences also affect the nuclei, as is the case in other afferent systems such as the olfactory and visual systems and the muscle spindles.

Fibers from the dorsal column nuclei decussate in the medulla and ascend as the contralateral medial lemniscus to terminate on third-order neurons in the VPL of the thalamus. Lemniscal fibers are restricted to the VPL. Stimulus and location specificity are maintained in the VPL with units responding only to stimulation of a localized area on the contralateral side of the body. The receptive fields of the extremities are small distally and larger proximally.

Third-order fibers then pass to the sensory cortex in the parietal lobe. Topographic arrangement is maintained in the primary sensory cortex. The same three cortical areas are involved in interpretation of dorsal column sensations as noted previously for the spinothalamic functions.

The traditional concept of dorsal column function is that two modality-specific spinal sensory pathways carry sensory information to higher centers where a complex spatiotemporal analysis is carried out. The dorsal column system was believed to transmit vibration, proprioception, and fine touch, whereas the anterior columns transmit pain, temperature, and crude touch. This view has not been entirely supported by animal experiments or human case reports. A new analysis of dorsal column function has been proposed by several investigators to explain the deficiencies of earlier theories. According to this concept, the anterolateral system is concerned with modality analysis of stimuli passively impressed on the animal and the dorsal column with spatiotemporal analysis of objects that must be actively explored by motor movements in order to be discriminated. Thus, by this view, analysis and extraction of information regarding moving stimuli, as in stereognosis, is the function of the dorsal columns. (See Wall, 1976; Wall and Dubner, 1972; Azulay and Schwartz, 1975; Frommer et al., 1977; and Ross et al., 1979.)

Tactile

Multiple receptors including Merkel disks, Meissner corpuscles, and free nerve endings are believed to be involved in the perception of tactile sensation. Touch impulses are carried by large myelinated fibers in both the spinothalamic
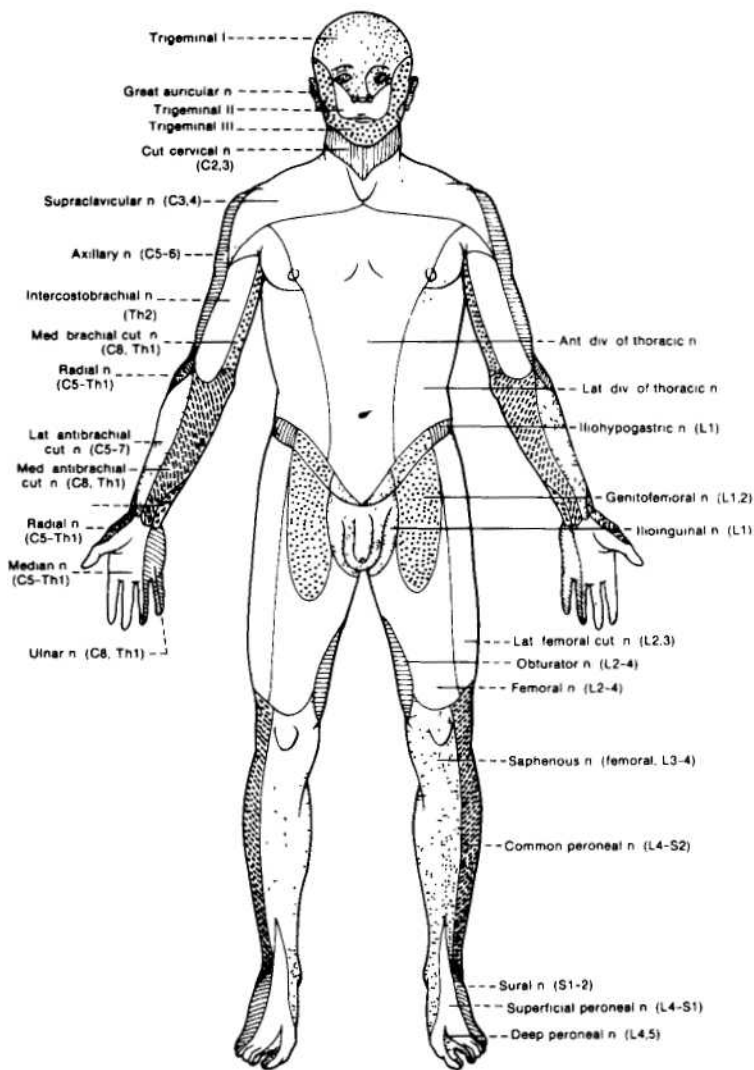
Figure 67.4A
Anterior view of the cutaneous distribution of the peripheral nerves.
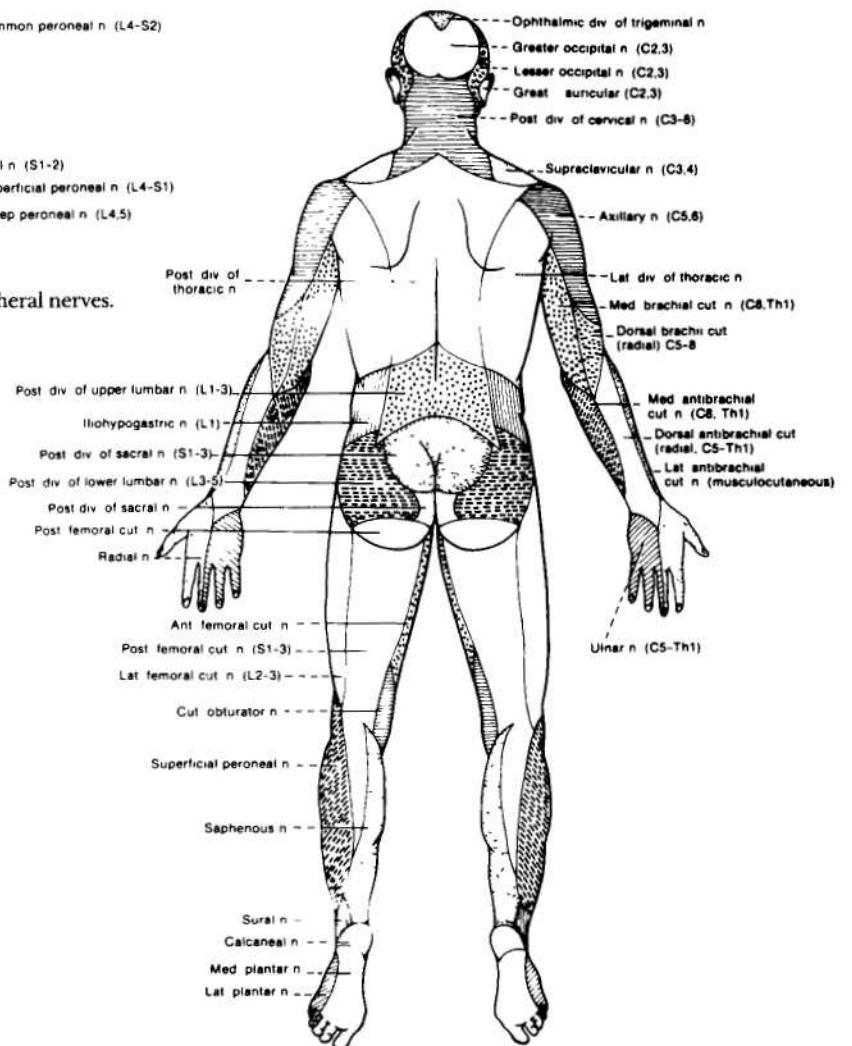
Figure 67.4A
Posterior view of the cutaneous distribution of the peripheral nerves.

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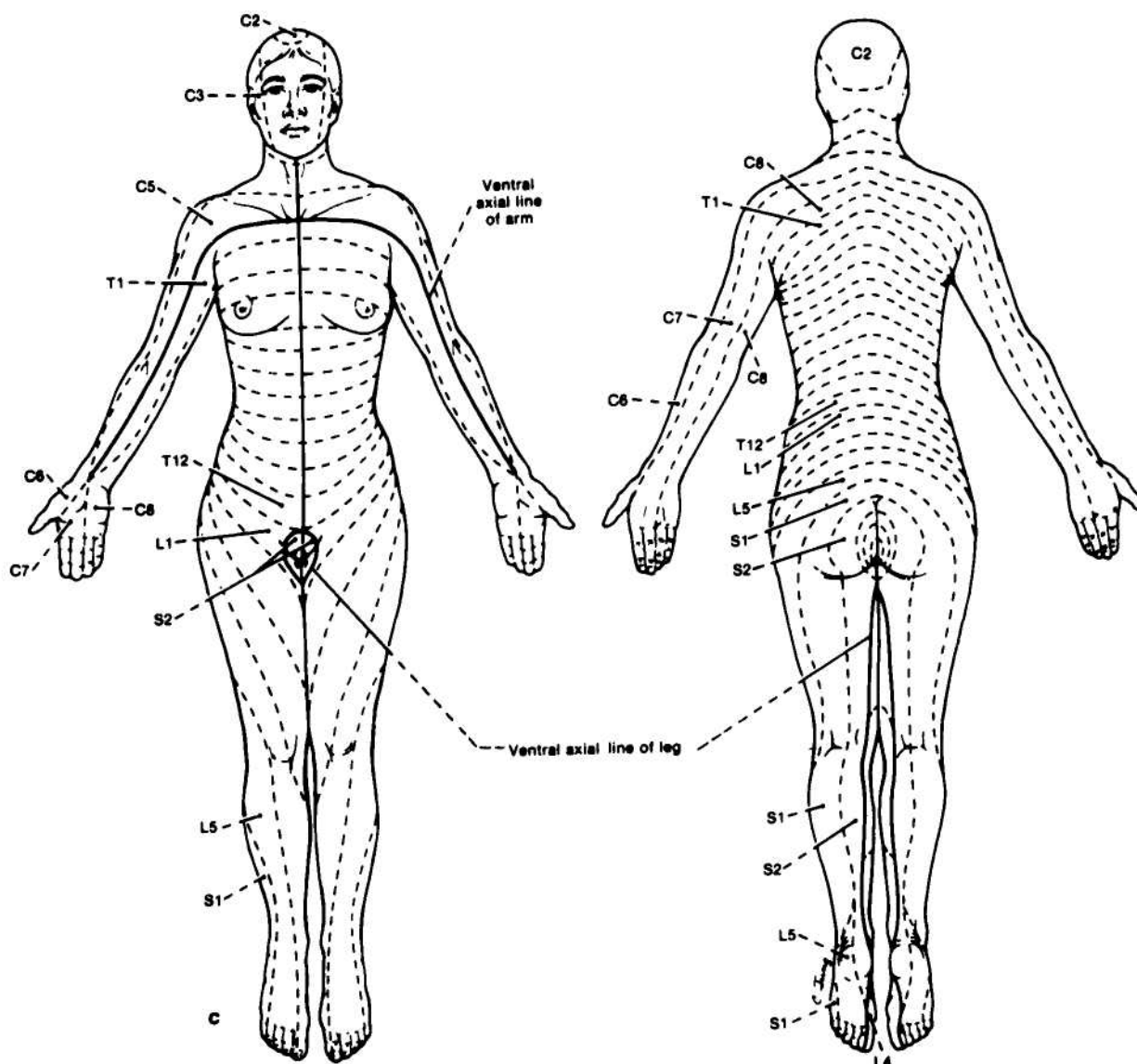
Figure 67.4B
The segmental innervation of the entire body. This figure and Figures 67.4A (opposite) are reprinted with permission from DeJong, R.N. The Neurological Examination, 4th ed. New York: Harper & Row, 1979

and dorsal column systems. Light touch appears to be carried by both. Discriminative tactile sensibilities such as two-point localization and texture recognition are carried in the dorsal columns. Tickle and itch are carried by the spinothalamic tracts. Lesions that destroy pain sensation, such as cordotomies, also ablate these sensations. All components end in the VPL of the thalamus and then project to the cortex as described above.

Clinical Significance

Careful determination of the pattern and type of abnormal sensation often provides valuable assistance in the localization of lesions of the nervous system. Attention should be directed to relate the sensory findings to other abnormalities uncovered in the remainder of the neurologic exam with reference to the anatomy of the sensory system. Lesions may involve any of the functional components of sensation described in the Basic Science section.

Both decreased sensation and sensory perversions may result from disorders of sensory receptors. The pain and paresthesias resulting from burns or chemical irritations of the skin may result from disturbances of these structures. Receptor numbers decrease with advancing age, a finding that may explain the commonly observed diminution of vibratory sensation in elderly individuals.

Disorders of peripheral nerves are a common cause of sensory disturbances. Some or all sensory modalities may be involved, depending on the etiology of the lesions. Compressive and anoxic lesions affect large-diameter fibers first and affect proprioception, discriminative tactile sensation, and fast pain before slow pain is diminished. Local anesthetics such as novocaine preferentially affect C-fiber function and reduce slow pain before temperature, fast pain, touch, and proprioception. Nerves innervating the face or body overlap in the midline, resulting in the finding that organic analgesia usually ends slightly lateral to the midline. Causes of peripheral neuropathy may be briefly classified as follows:

1. *Mononeuropathy:* involvement of one nerve, sensory loss in distribution of single peripheral nerve (Figure 67.4)
   a. *Traumatic:* usually affects the ulnar or radial nerve ("Saturday night palsy") in the upper extremity, peroneal nerve (from crossing legs) in the lower extremity.
   b. *Entrapment:* most common in the median nerve at the wrist (carpal tunnel syndrome)
   c. *Vascular:* sudden onset, usually involves larger nerves, may affect diabetics (third cranial nerve or femoral nerve)
2. *Mononeuropathy multiplex:* involvement of multiple peripheral nerves over time. May be seen in diabetes or vasculitis.
3. *Polyneuropathy:* symmetrical gradual progression of sensory findings affecting most distal nerves first and progressing proximally. Usually affects the lower extremities first, then the uppers. Produces a "stocking" or "glove" type of sensory loss. Most commonly results from toxic or metabolic disorders.

Conditions that affect the dorsal roots or dorsal root ganglia produce sensory alterations in the distribution of skin segments supplied by that segment of the spinal cord. These skin areas are termed dermatomes (Figure 67.4). There is widespread overlap in the innervation of successive dermatomes, and it may not be possible to map the sensory loss of a single dermatome. Lesions may produce analgesia or pain, often shooting or lancinating, in the distribution of the dermatome. Herniated intervertebral disks may cause this type of sensory loss and will produce motor findings if the ventral roots are involved. Herpes zoster (shingles) can produce pain in the distribution of dorsal root fibers associated with characteristic skin lesions over the affected dermatome. Carcinomatic meningitis can predominately affect the dorsal roots in either a focal or diffuse distribution. Prior to the introduction of antibiotic therapy, the tabes dorsalis form of neurosyphilis was a common cause of disease of the dorsal roots.

Because of the separation of sensory pathways in the spinal cord and brainstem, lesions in these regions often affect certain sensory modalities to a greater degree than others, resulting in a dissociated sensory loss. Transverse lesions of the cord produce loss of all modalities below the level of the lesion. The level for pain and temperature is most distinct, whereas it is often difficult to delineate changes in tactile sensation as a result of the more diffuse pathways for this modality within the cord. Lateral lesions compressing the cord may produce early sensory changes below the level of the lesion due to the lamination of spinothalamic fibers which places those fibers from lower segments most laterally. Dorsal compressive lesions may affect proprioception and tactile discrimination without pain and temperature loss. Certain metabolic conditions such as pernicious anemia and tabes dorsalis affect the dorsal columns preferentially. Intramedullary lesions may interrupt crossing pain and temperature fibers at one level. An example of this type of disorder is syringomyelia in which a cyst or syrinx most commonly occurs in the cervical region resulting in a capelike loss of pain and temperature sensation while sparing other sensory modalities. Brainstem lesions can interrupt ipsilateral trigeminal sensation and crossed sensory fibers from the body resulting in crossed sensory loss on the face and body.

Thalamic lesions produce a loss of all sensory modalities on the opposite side of the body. This may be accompanied by abnormalities of sensation including paresthesias, hyperesthesias, or hyperpathias in which somatic stimuli result in unpleasant, often burning pain. Lesions of the thalamocortical radiations produce contralateral sensory loss but not central pain syndromes.

Lesions of the parietal cortex produce impairment of cortical sensory functions. Although a slight raising of the threshold for exteroceptive and proprioceptive sensations may be observed, complete loss of sensation is never observed. Primary sensory modalities must be relatively intact to diagnose loss of cortical sensory function.

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